MISSION BRIDGE
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Your Brain and Neurofeedback: A Beginner's Manual

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Introduction to Biofeedback and Neurofeedback

Biofeedback as a field has been growing since the late 1960s. This form of training and treatment uses monitoring instruments attached to the body to "feed back" to people information on the functioning of their bodies. In this way, people view information of which they are not normally aware, such as hand temperature, blood pressure, number and depth of breaths being taken, level of muscle tension in any target muscle, or the electrical activity of their brains. It has been established that, once people have more detailed access to information on what their bodies are doing, they are able to either consciously or subconsciously alter or control those functions. In this way, people with tension headaches can learn to relax tense muscles, people with urinary incontinence can learn to control their bladders, people with Raynaud's disease (circulation difficulties in the extremities) can learn to warm themselves by increasing blood flow, and people with high blood pressure can learn to control that symptom.

Of particular interest to psychologists is the electrical functioning of the brain. The form of biofeedback that enables people to alter brain electrical activity is called

"neurofeedback" (or EEG biofeedback). The reason that neurofeedback is of special concern to psychologists is that the brain is a central contributor to the emotions, physical symptoms, thoughts, and behaviours that define many problems for which people seek psychological consultation. Problems being addressed through neurofeedback include anxiety, depression, attention deficit and hyperactivity disorder, memory difficulties and general cognitive functioning, learning disabilities, head injury, obsessive-compulsive disorder, chronic pain, epilepsy, immune system disturbances, panic attacks, sleep disturbances, and more. Scientists have identified specific patterns of brainwaves that contribute to a lack of wellness, and that tend to be related to disorders such as some of those listed here.

The Mind-Body Connection

Biofeedback, including neurofeedback, is based on the increasingly accepted idea of the interconnectedness of mind and body. Recognition of the mind-body connection is becoming a standard in the practice of a healthy lifestyle, and many health professionals assert that the health of mind is intimately connected with the health of body. Is your brain "mind" or "body"? The answer that makes the most sense is, "It is both."

During the past 30 years, there has been a powerful scientific movement to explore the mind's capacity to affect the body and to rediscover ways in which the mind affects and is affected by the body and all of its functions. Investigation of the mind-body connection has been encouraged by the rise in chronic illnesses that appear to be related to environmental and emotional stress: heart disease, cancer, depression, arthritis, and asthma included. Also being examined are specific links between mental processes and the functioning of immune and nervous system functioning.

Mounting evidence of the mind-body connection includes the following findings and facts:

- Researchers in the area of obsessive-compulsive disorder have found that the changes that occur during "talk therapy" are visible in "before" and "after" PET scans. PET scans measure the metabolic activity in various parts of the brain. Thus, talk therapy has been found to alter brain functioning.

- Researchers in the area of fitness found that a group of "couch potatoes" who simply closed their eyes and visualized doing physical exercise actually increased their muscle mass by 16%.

- If a person imagines moving a particular body part, the part of the cortex associated with that body part will show some indication that the body part actually IS moving.

- Strong negative emotions, which can be triggered during abuse situations, trigger the release of toxic neurochemicals such as cortisol, which dramatically influence the developing brain in a way that makes people more vulnerable to anxiety and depression throughout the lifespan.

- One study found that medical students who experienced high levels of stress during exam week produced lesser levels of a particular messenger molecule, which resulted in compromised immune system functioning. Thus, emotional stress (mind) translated into physical effect (body) and many of them got sick. This same messenger molecule has been shown to be related to the immune system's ability to fight some types of cancer (interleukin-2).

- Antidepressant drugs change the availability of neurochemicals in the brain, such that changes in thought, mood, and behaviour result.

These are just a few of the phenomena that make it increasingly difficult to talk about the mind and the body as separate entities. Mind changes are body changes, and body changes are mind changes. Neurofeedback is a therapy of training the mind and body to function in a more optimal way in order to ease negative emotional, cognitive, physical, and behavioural experiences. It is seen by many people as a viable alternative to medication, instead encouraging and nurturing the body's own ability to reorganize, change, and heal itself in a natural way.

In the remainder of this paper, you will learn about:

- The Birth of Neurofeedback as a Discipline
- Quantitative Electroencephalography (qEEG)
- The Variables of Brain Functioning
- The Experience of Neurofeedback
- Whether Neurofeedback May Be Right for You.

The Birth of Neurofeedback as a Discipline

In the early 1960s at the University of Chicago, psychologist Joe Kamiya made the discovery that some of his research subjects could learn to alter the power and speed of their brainwaves if they were provided with information on the activity of their brains.

Barry Sterman also did research involving neurofeedback in the 1960s. He found that cats could learn to alter their brainwaves if they were given rewards for producing the "goal" brainwave. With repeated exposure to neurofeedback training, the cats became adept at doing so. Sterman's subsequent research project studied the effects of rocket fuel toxicity. Sterman injected cats with the rocket fuel, and found a close relationship between the cats' seizure activity and the amount of exposure to rocket fuel. The more rocket fuel, the more seizures. It is always scientifically pleasing to find a straightforward relationship, and Sterman began to make some conclusions from his results. However, he began to get results that did not fit the relationship he had been establishing. Some of these cats seemed to remain seizure free, even at dosages that had made other cats erupt into seizures. Upon further examination, Sterman found that it was his neurofeedback cats (that had been transferred to the rocket fuel study) that were throwing off his results. This finding was impressive: the cats who had received neurofeedback had a higher seizure threshold than did other cats. There was a clear clinical application that had not been apparent before. Research on neurofeedback for epilepsy began.

While these were astounding discoveries, this technique soon fell into disrepute for a number of reasons: some parties made claims for neurofeedback that were not yet supported by science; other involved parties formed a close link with "flakier" movements that compromised the scientific integrity of the discipline; and still others thought that this technique was too close to "mind control." The result was that neurofeedback was kept only barely alive by a few diehard pioneers until its revival in the 1980s.

The field of neurofeedback has grown very rapidly in the last 20 years, and especially in the last 10 years. The number of practitioners worldwide is approaching 2000, with the bulk of those practitioners residing in the U.S.A. There is a small scattering of practitioners across Canada. The field is beginning to recover from the low esteem in which it was formerly held – now, the science is catching up with the claims that have been made for its efficacy. Even while new information is being collected and published, many health professionals such as psychologists, psychiatrists, and family physicians are unaware of current developments in the field.

Quantitative Electroencephalography (qEEG)

he electroencephalograph (EEG) has been studied and applied since the early 20th century as a way of looking at the electrical functioning of the brain. Billions of neurons in the cortex, which are also influenced by structures that are deeper beneath the cortex, produce electrical activity that is readable by attaching sensors to the scalp. Because of the skull, the impulses are very faint at the level of the scalp. The electroencephalograph amplifies those faint impulses so they may be viewed by the human eye.

As digital computer technology developed in the 1960s and 1970s, scientists were able to more precisely examine a person's electrical brain functioning in ways that were not possible through a simple visual inspection of raw brain wave tracings. The computer can calculate and make visible many features of the EEG that the human eye can not. This form of computer analyzed brainwaves is called quantitative EEG, or qEEG.

Recording of the qEEG involves placing an elastic cap on the head, with 19 sensors held in place on the scalp. In addition, a clip on each earlobe provides a reference point for the brain activity. Because there is very little electrical activity in the earlobes, they are much more electrically "dead" than scalp sites. Once the cap has been placed, each of the 19 sensors is checked to ensure that it has a good connection with the scalp. The electrical activity at each of the 19 scalp sites is then recorded and calculated by comparing it to the more electrically neutral earlobe. Data on the electrical functioning of the brain is recorded simultaneously at each of the 19 sites. One set of data is recorded with eyes open, and a second set is recorded with eyes closed. During recording of the brainwave data, it is very important to remain as still as possible so as not to contaminate it with a lot of electrical "noise."

Prior to the quantitative analysis of the brainwave recordings, the data is "artifacted." An artifact is defined as any activity that can be seen in the EEG recording that is not actually brain activity. For example, muscles also operate electrically. This means that any muscle tension on the scalp, the forehead, or anywhere near the sensors will be picked up by the sensor. This "artifact" is electrical noise that must be cleaned out of the brainwave recording in order to ensure that the results reflect brain activity and not some other irrelevant information.

Once the brainwave recording is cleaned up, it is put through a number of analyses by the computer, and the result is a collection of measurements. A number of variables of brain functioning are calculated and compared to a database comprised of a collection of measurements taken from people who are free of difficulties, injury, and disease. Scientists have created such databases to enable the comparison of one individual's brain functioning to a group of others of the same age and gender. In this way, an individual's brain may be evaluated in terms of how much its functioning departs from "normal" or "optimal." These variables of functioning and the degree to which they are higher or lower than optimal are of interest in assessing the strengths and weaknesses of an individual's brain functioning. An outline of some key variables follows.

The Variables of Brain Functioning

Quantitative analysis of brainwaves produces measurements of frequency, amplitude, symmetry, coherence, and others (these measures are described below). The report of the analysis provides a value for each of these variables for each of the 19 sites at which the brainwaves have been measured. Each value represents how much the activity at a given site differs from usual. Values that are positive (i.e. +2.4) represent activity that is higher than usual, and values that are negative (i.e. –2.4) represent activity that is lower than usual. Because each value represents how different a site is from usual, the number "0" represents a close match with the brains to which an individual's brain has been compared.

Frequency

Frequency refers to the rate at which a brainwave repeats its cycle within one second. The number of cycles per second is called "hertz" (Hz). The more times a brainwave repeats its cycle per second, the FASTER it is said to be. Some practitioners divide the frequency of brainwaves into categories:

- 0-4 Hz Delta
- 4-8 Hz Theta
- 8-12 Hz Alpha
- 12 Hz and above Beta

Delta waves occur primarily during sleep, however, they are also present to various degrees throughout normal brains when awake.

Theta waves are also slow waves, and are often associated with twilight states such as that between sleep and wakefulness. Theta is much more complicated than this simple explanation, as it has also been shown to be important in memory consolidation.

Alpha is thought of as an idling rhythm, sometimes associated with relaxation or meditation. Alpha is also associated with multi-tasking. For example, a person is multi-tasking when he is focused on many things at once such as ironing a shirt, listening to the weather report, and wondering what is for breakfast. Alpha is produced by large groups of neurons that are not engaged in any particular task, but rather, are standing at the ready to serve a function should they be called upon. Alpha may be likened to "the ready position" in volleyball, or a car sitting in neutral.

Beta is the fastest and most active form of brainwave, and is associated with focus and concentration. When excessively present, Beta can contribute to anxiety. Consider how much focus and concentration one may have while driving down a busy freeway in a snowstorm: this is focus that is exaggerated to the point of possible anxiety.

Frequency is one of the parameters of brain functioning that has to do with the speed of the brainwave or how many times it repeats itself per second. All sites of the brain show all frequencies of activity, however, the amount of a particular frequency that is desirable depends on where it is located in the brain. In general, concentrations of alpha are found at the back of the head, and faster waves are more prominent at the front of the head. Thus, no brain wave is good or bad. It is simply more or less adaptive, depending upon where it is concentrated in the brain.

Amplitude

The amplitude of the EEG is defined as the voltage in microVolts. Another way to think of amplitude is in terms of power or how much energy is being put into a particular brainwave. Put simply, the amplitude can be thought of as the "volume" of the brainwave. A high amplitude theta signal at a particular site means that a lot of energy or power is being put into theta at that site.

Symmetry

Symmetry is the degree to which the activity at a particular site on one side of the brain is similar to the corresponding site on the other side. In this way, a person can serve as his or her own reference. For the most part, the activity at one site should look similar to the activity at the corresponding site on the opposite side of the head. Recording data simultaneously from each of the 19 sites enables the symmetry between left and right to be calculated.

Coherence

Coherence is a measure of how closely each site communicates with each other site. There is an ideal amount of communication that should take place among sites. With too much communication, the brain is devoting too much energy to doing the same thing – this is not a good use of resources. With too little communication between sites, the brain also is not using its resources most optimally. Communication in the brain may be thought of in the context of the crew on a sailing vessel. If the captain issues an order for some of the crew to solve a problem on one side of the ship, it would not be wise for the entire crew to rush over and leave the rest of the ship unattended. Further, if none of the crew communicated with each other, the running of the ship would quickly become disorganized. Recording data simultaneously from each of the 19 sites enables calculation of the coherence (or level of communication between each pair of sites).

The Experience of Neurofeedback

Once the specifics of an individual's brain functioning have been assessed, psychologists look for connections between troubling symptoms and the strengths and weaknesses that have been identified by the qEEG. While the qEEG often reveals generalized problems in brain functioning that will influence many aspects of the individual's experience, people most often seek assistance from psychologists for a particular difficulty – the qEEG variable that most closely matches the complaint of the individual will be addressed first.

It is on the basis of this "strengths and weaknesses" profile that the psychologist will write a computer program to assist the individual in the learning process that will lead to the enhancement of strengths, or, more often, the amelioration of weaknesses. For example, if qEEG assessment shows that an individual has too much slow activity (theta) and not enough fast activity (beta) at the front of the brain, and that person's complaint is of attentional difficulties (which matches the complaint of frontal slowing), training will consist of inhibiting the slow (theta) activity and enhancing faster activity (beta).

The individual receiving neurofeedback training wears a clip on each ear, one sensor on the forehead, and one sensor on the site that has been targetted for training (i.e. the site(s) that the qEEG indicated was different from usual). The sensor that is designated as the "target" site is referred to as the "active sensor." The brainwave activity recorded by the active sensor is displayed on the computer monitor, perhaps as a coloured bar. In the example above, where the goal is to enhance faster activity (beta), the coloured bar represents beta and fluctuates up and down with the individual's beta waves. Also visible on the screen is a "high jump bar" or threshold, set at an appropriate level such that the beta activity is able to "jump over it" (exceed the threshold) at least 60% of the time. Each time the beta "jumps" over the "high jump" (i.e. each time the beta recording reaches or exceeds the goal threshold that was set for it), the computer emits a pleasant tone. With repeated exposure to this form of feedback, that is both visual and auditory, the brain begins to recognize a relationship between its own activity and what it is observing on the computer monitor. In other words, the brain begins to recognize itself. This is when learning begins to take place.

Once the brain "catches on" to what it needs to do in order to make the high jump successfully and to hear the pleasant tone, it begins to do so more consistently. This sounds rather unbelievable, however, it has been established that this process occurs. Fortunately, the changes are quantifiable and observable through measurements taken during neurofeedback sessions, as well as through follow up qEEG assessments.

Learning may be looked at in three ways: subconscious learning, the forming of a conscious association between feelings and brain states, and the development of flexibility in neural pathways.

Subconscious learning occurs in a process whereby the brain, at a level below awareness, begins to recognize itself on the computer monitor and to make the changes required to keep the bar above the high jump. As this is occurring, the individual may feel quite disconnected from the process. People feel as though they are simply watching the display and listening to the tones, without experiencing it as a personal process being driven by their own neural activity. This learning is on a subconscious level. Remember, cats and other animals can learn to alter their brain functioning when appropriate rewards are utilized – they certainly are not consciously considering what they need to do in order to receive the reward. This learning process occurs over time and outside the level of conscious awareness.

The second way that learning occurs is through the conscious association between indications that the target is being met (i.e. the visual and auditory cues) and how the individual feels. Often, a description of how it feels to meet the target defies words. For example, many people are unable to express in words what "more alpha" feels like although they can tell when it is occurring. This process of learning is conscious, and involves the development of an awareness of sensations in one's body that was not present before. In this way, individuals are able to voluntarily do what is necessary in order to produce that sensation at will. There is the sense that, "this is what it is supposed to feel like when I produce more alpha."

Finally, change through neurofeedback occurs as a result of exercising underdeveloped neural pathways. The more the brain practices moving into a more optimal state, the more flexible it will be in responding to demands.

Neurofeedback is seldom used in isolation from other techniques. It is usual for a session with your psychologist to include neurofeedback as well as other techniques such as EMDR and/or cognitive-behavioural exercises to support the changes you would like to make in your life.

Is Neurofeedback Right for You?

Engaging in neurofeedback requires a strong commitment, as people may not experience the beneficial effects for ten or more sessions. Some conditions will require forty or more sessions. It is usually not helpful for people to engage in a highly limited number of sessions, as change does not occur quickly. It requires a time commitment as well as a financial commitment, and you must be prepared for both. Preliminary indications have shown that the changes appear to be permanent, with booster sessions sometimes being necessary if some type of life experience or use of a substance compromises gains that have been made.

Neurofeedback is very helpful for many people, depending upon the particular problem that they want to address. Those who are interested should be aware that it is a form of training that is considered experimental by many people. You should read the attached consent form carefully for more information.

Neurofeedback is a healthy alternative to other forms of treatment that are more invasive, such as the use of medications that may have troubling side effects. Neurofeedback, used by qualified practitioners, is largely free of side effects. Possible side effects that may occur are managed as they come up, by making slight changes to the way in which treatment is delivered. For example, a protocol to increase faster activity, if delivered late in the day, may make for some difficulty in sleeping that night. With slight modifications, side effects are easily managed. Another possibly uncomfortable effect of neurofeedback is emotional: when changing the activity of the brain, it is possible that a person may notice an emotional change such as the surfacing of difficult emotions that you may have experienced in the past. While this is sometimes initially troubling for people, it also forms an integral part of the treatment as people learn to better manage their emotions and to process past experiences that may have been difficult.

As you think about whether or not to engage in this process, you should:

- Consider the time involved
- Consider the cost involved
- Consider your commitment to this process
- Ask lots of questions of your psychologist
- Do your own research to make an educated decision about whether or not this process is right for you
- Review the attached consent form closely with your psychologist
- Consider whether neurofeedback might be a useful addition to other forms of treatment such as psychotherapy, physical therapy, medication, etc. or whether one of these other forms of treatment might be appropriate for you.

This document was intended to provide preliminary information regarding the process of neurofeedback, however, a great deal of information is available to you upon request. Your psychologist can provide you with copies of scientific papers that describe how neurofeedback is used to treat your problem. Further, you may begin to do your own research on the internet. The following websites contain information that may be of interest to you. The content is not regularly monitored by your psychologist, so use your own discretion in evaluating each site as you collect information.